

A GUIDE
TO
URINARY ANALYSIS

PIFFARD.

A GUIDE
TO
URINARY ANALYSIS,

FOR THE
USE OF PHYSICIANS AND STUDENTS.

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PREFACE.

THE writer ventures to offer the following pages to physicians and students, in the hope that the simple and easy manipulations described may encourage the more frequent and more thorough investigation of the urinary secretion. Availing himself largely of the materials scattered through different treatises upon the subject, his aim has been to reduce them, as far as practicable, to a uniform system of manipulation, to simplify the calculation of results, and to arrange and modify the necessary apparatus, so that the various operations may be conducted speedily, accurately, and at slight expense. The Approximative method, or the quantitative estimation of various substances by the bulk of their precipitates, is simply what its name implies, and it would not be admitted into a laboratory devoted to exact chemical researches; but, for ordinary clinical purposes, the range of error is not sufficient to seriously modify the desired results.

In order to render this manual as compact and brief as possible, unnecessary verbiage and needless repetitions have

been avoided, and some few facts in connection with the subject, with which the physician is necessarily acquainted, and which the student is sure to learn from other sources, have been purposely omitted.

H. G. P.

123 EAST 35TH STREET.

A GUIDE TO URINARY ANALYSIS.



CHAPTER I.

INTRODUCTION.

A THOROUGH and ultimate analysis of urine belongs to the province of the professional chemist, but a very useful degree of information concerning the character of this fluid may be obtained by the physician, with the aid of a little apparatus, and the employment of a few simple and easily learned manipulations; and the intention of the following pages is to indicate the processes necessary to enable the operator to obtain the desired information, with the least expenditure of time and trouble, due regard being had to the necessary element of accuracy.

The principal sensible and physical qualities of urine being familiar to all, renders their discussion in

this place unnecessary; we shall therefore confine ourselves to the consideration of such facts only as require for their determination manipulative assistance.

Urine, as it comes to us for examination, usually consists of two portions—first, a fluid, containing in solution a number of different salts, and also various organic substances resulting from the physiological or pathological processes constantly in operation; second, of a deposit, which may consist of a slight and barely distinguishable cloud of mucus, or, on the other hand, may occupy a very considerable portion of the vessel containing the specimen. The character of this deposit is usually and most readily learned with the aid of the microscope; and to this instrument, in fact, we look for almost all of our information concerning the insoluble substances encountered, with the exception, perhaps, of availing ourselves of the well-known fact, that deposits of the urates may usually be carried into solution by the simple expedient of warming the urine, thus enabling us to determine in a moment whether or no the

main bulk of the deposit consists of these salts. Leaving, therefore, to the microscope its usual duties in this connection, we will simply consider the chemistry of such soluble constituents of urine as chiefly concern us from a clinical stand-point.

If the whole quantity of urine passed in twenty-four hours can be obtained, its measurement will give us its amount, and the mixture will afford us an average sample for further investigation. This, however, except in hospitals and in the case of patients confined to bed, is rarely practicable, and hence we are usually obliged to content ourselves with specimens passed upon retiring and upon rising. These should be brought in different bottles, in order that separate preliminary examinations may be made, and the results compared with an examination of the mixture, as the most striking differences will sometimes be encountered.*

* A patient recently sent us a number of specimens of urine passed on going to bed, which all contained sugar, while the urine passed the following mornings contained none. This naturally led to a more favorable prognosis (justified by the result) than if we had been obliged to form an opinion from an examination of specimens of the mixed urine, which would have constantly responded to the test for sugar.

The *quantity* of urine passed is usually expressed, in this country and in England, in fluid ounces or pints; the fluid ounce (U. S. standard) being equal to a volume of distilled water weighing 455.69 grains Troy, and constituting one sixteenth of a pint.* This measure will be meant when speaking of fluid ounces, drachms, etc.

The employment of the grain system of weights has been deemed advisable, because it is the one in use in our pharmacy, and the one most familiar to those for whom these pages are written. The formulæ of the standard solutions, however, are so constructed that the solutions may be used by either the grain or gramme standard.

* The fluid ounce in use in England (Imp. measure) weighs 437.5 grs., (=1 oz. av.), and the Imp. pint contains 20 fluid ounces.

CHAPTER II.

APPARATUS.

THE apparatus required for urinary analysis will depend, of course, upon the extent and thoroughness with which one desires to investigate the subject. For ordinary clinical purposes, it need not be extensive or costly. A few words will be said concerning some of the apparatus mentioned hereafter.

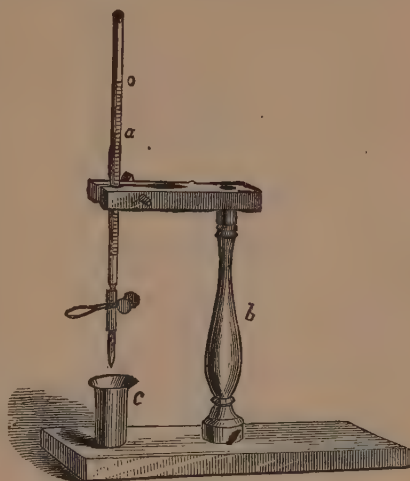


Fig. 1.

Test-tubes and

Stand.—Tubes about five inches in length will be found the most convenient for ordinary use. The

stand should be provided with pins upon which the tubes can be inverted for drainage, and to keep them free from dust.

Beakers of two-ounce capacity (Fig. 1, *c*) will be found most convenient for purposes of titration. Larger ones may be kept for other uses.

Graduates of the usual conical form may be used for measuring large quantities of urine where strict accuracy is not required; but, for measuring smaller portions, either a burette or measuring pipette must

be employed.

Burette.—The most convenient form of this instrument is the one devised by Mohr. It consists of a graduated glass tube, to the lower end of which a small delivery tube is connected by means of a short piece of rubber tubing, the calibre of which can be obliterated by the



Fig. 2.

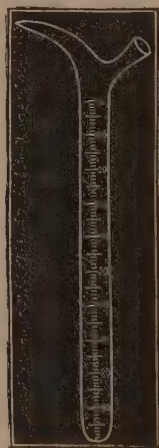


Fig. 3.

aid of a spring-clip, (Fig. 1, *a*.) The burette is sup-

ported upon a convenient stand, (Fig. 1, *b*.) This form of burette will answer for every analysis mentioned hereafter, except the one known as the "chameleon process," in which a solution of permanganate of potash is employed. Rubber acts prejudicially upon this solution, and hence the burette in which it is employed must be wholly of glass. This may be obtained in a Mohr's burette made with a glass stop-cock; or the cheaper instruments of Gay Lussac, (Fig. 2,) or of Bink, (Fig. 3,) may be used. These latter, however, are not as convenient in use, nor as easily cleaned as Mohr's.

Retort-stand,
Bunsen burner,
and *Water-bath* are shown in Fig. 4.

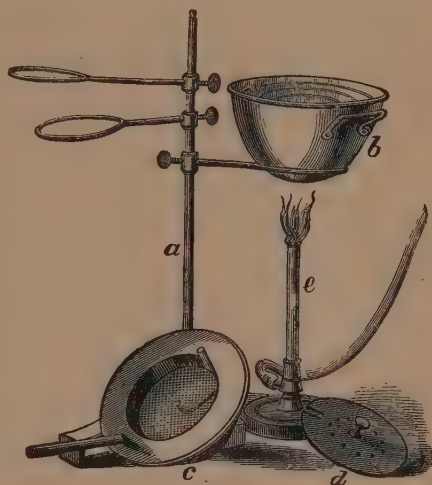


Fig. 4.

To the water-bath may be fitted one of the author's water-ovens, (Fig. 4, *c* and *d*.) This little piece of

apparatus answers the purpose very well, and is much cheaper than ordinary independent water-ovens,

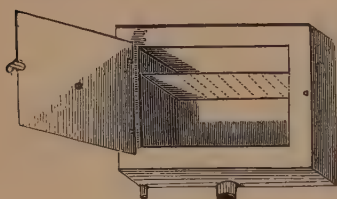


Fig. 5.

(Fig. 5.)

Bohemian flasks (Fig. 6) of varying capacities, will be required, and also *evaporating dishes* and cap-

sules of the best porcelain, from two to four inches in diameter, and as shallow as possible.

A *measuring pipette*, for delivering small definite quantities of urine, etc., is an absolute necessity.



Fig. 6.

We have found one of the form and with the graduations shown in Fig. 7 very useful.

It is used in the following manner: Relax the spring and suck into the tube a sufficient quantity of urine; release the spring,

and the urine sucked up will, of course, remain. Then carefully relax the spring, and permit the urine to flow out of the tube until its upper level is opposite the proper mark. The point of the pipette is then brought into the beaker and its contents delivered. In this way the proper amount of fluid can

be delivered more rapidly and more accurately than if measured in an ordinary graduate.

An apparatus for *Rapid Filtration* will facilitate the collection of precipitates. The one devised by the author (Fig. 8) is a modification of that of Bunsen.* It is used

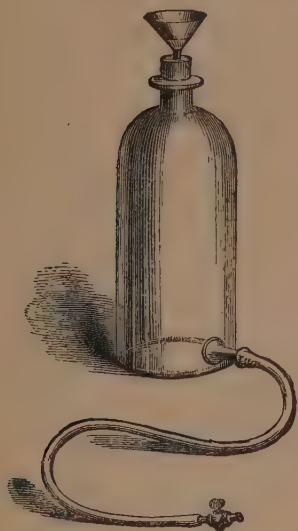


Fig. 8.

is desired to filter is poured into the funnel. If,

in the following manner: The platinum funnel point or *conus* and

the filtering-paper are arranged as directed by Bunsen. The glass bottle, which may be a Thudichum's douche or other vessel of similar construction, is filled with water and the cork adjusted. The fluid which it

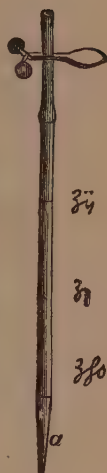


Fig. 7.

* For a description of Bunsen's apparatus and method of using it, see Fresenius's "Quantitative Analysis," Am. ed. p. 66.

now, the stop-cock be opened and the water allowed to flow out of the bottle, the air within will be rarefied, inducing a more rapid flow of the contents of the funnel than would otherwise occur.

The *Balance* and *Weights* should be delicate and accurate. Those furnished by Becker & Sons, of this city, are, we believe, the best for the price that can be obtained. Capped bottles for acids, (Fig. 9,) plainer bottles for other reagents, and



Fig. 9.



Fig. 10.

six-ounce bottles for standard solutions, should be obtained. In addition, watch-glasses, filtering-paper, funnels, brushes

for cleaning test-tubes, wash-bottles, (Fig. 10,) etc., will be required.

A few other pieces of apparatus for special purposes will be described hereafter.

CHAPTER III.

REAGENTS AND STANDARD SOLUTIONS.

THE following reagents and solutions will be found necessary for the performance of the tests and analyses to be described.

REAGENTS.

Distilled water.

Absolute alcohol.

Sol. nitrate of silver.

“ chloride of barium,

“ nitrate of uranium.

“ sulphate of copper.

} 1 to 10.

Liq. ammoniæ.

Nitric acid.

Hydrochloric acid.

Sulphuric acid.

Acetic acid.

Nitroso-nitric acid.

STANDARD AND ACCESSORY SOLUTIONS.

The standard or test solutions for the quantitative determination of the various urinary ingredients should be made with the utmost care and most scrupulous regard for accuracy; for it must be borne in mind that in testing a small quantity of urine and calculating the result for a larger quantity, any slight error or inaccuracy will of necessity be increased in magnitude.

Volumetric analysis, or the method by *titration*, depends upon the employment of certain solutions of known strength and chemical equivalence, by the aid of which the quantities of other substances existing in solution may be accurately ascertained. The so-called "normal" solutions, much used by the French, are made by dissolving the atomic weight of the reagent, expressed in *grammes*, in one *litre* of distilled water. With these solutions, however, we have nothing to do, but employ instead what are termed standard solutions,* the formulæ of which vary with the convenience of the operator. Those

* Abbreviated hereafter into S.S.

which we employ, with the exception of the one used for the analysis of albumen, are all of such strength that 200 fluid grains of the particular solution correspond to 1 grain of the substance whose quantity we wish to determine. In some analyses, certain accessory solutions enable us to determine the exact amount of standard solution required for the proper performance of the operation.

UREA.

Sol. Nitrate of Mercury.—Dissolve 38.6 grains (or grammes) of pure red oxide of mercury in the least possible quantity of nitric acid, with the aid of a little heat; transfer the *whole* of this to the mixing-flask, and dilute with distilled water to 1000 grains, (or c. c.) 200 grains of this S.S. are equivalent to 1 grain of urea, or 20 c.c. of S.S. \Rightarrow 1 decigramme.

Baryta Solution.—Mix one volume of a cold saturated solution of nitrate of baryta, with two volumes of a similar solution of caustic baryta.

Sol. Carb. of Soda—about 1 to 10.

URIC ACID.

Sol. Permanganate of Potash.—Dissolve 2.1 grains (or grammes) of permang. potass. in 1000 grains (or c.c.) of distilled water. 200 grains of S.S. \Rightarrow 1 grain of uric acid, or 20 c.c. \Rightarrow 1 decigramme.

PHOSPHORIC ACID.

Sol. Chloride of Iron.—Dissolve 3.88 grains (or grammes) of pure iron in a sufficiency of hydrochloric acid, with the addition of a little nitric, and evaporate to dryness; dissolve the residue in a little water, and dilute to 1000 grains, (or c.c.) 200 grains of S.S. \Rightarrow 1 grain of phosphoric acid, or 20 c.c. \Rightarrow 1 decigramme.

Sol. Nitrate of Uranium.—Dissolve 35.5 grains (or grammes) of pure nit. of uran., free from moisture, in 1000 grains (or c.c.) of water. 200 grains of SS. \Rightarrow 1 grain of phosphoric acid, or 20 c.c. \Rightarrow 1 decigramme.

Sol. Acetate of Soda.—Dissolve 400 grains of acetate of soda in six ounces of water, and add 800 grains of acetic acid.

Sol. Ferrocyanide of Potassium—1 to 10.

SULPHURIC ACID.

Sol. Chloride of Barium.—Dissolve 15.25 grains (or grammes) of chl. barium in 1000 grains (or c.c.) of water. 200 grains of S.S. \approx 1 grain of sulphuric acid, or 20 c.c. \approx 1 decigramme.

Sol. of Sulphate of Soda—1 to 10.

CHLORIDE OF SODIUM.

Sol. of Nitrate of Silver.—Dissolve 14.53 grains (or grammes) of nit. of silver in 1000 grains (or c.c.) of distilled water. 200 grains S.S. \approx 1 gr. chlor. sodium, or 20 c.c. \approx 1 decigramme.

Sol. Chromate of Potash.—Saturated.

ALBUMEN.

Sol. Ferrocyanide of Potassium.—Dissolve 1.3 grains (or grammes) of ferrocyanide of potass. in 1000 grains (or c.c.) of distilled water. 100 grs. S.S. \approx 1 gr. albumen, or 10 c.c. \approx 1 decigramme.

SUGAR.

Fehling's Solution.—A number of different formulæ pass under this name. The one we are in the

habit of using is made by dissolving, first, 51.98 grs. (or grammes) of pure sulphate of copper in 500 grs. (or c. c.) of distilled water; second, dissolve 259.90 grs. (or grammes) of pure crystallized Rochelle salts in a solution of caustic soda, (sp. gr. 1.12,) whose volume is equal to that of 1000 grs. (or c. c.) of distilled water. One volume of the first solution, mixed with two volumes of the second, constitutes Fehling's Sol., 200 grs. of which \approx 1 gr. of sugar, or 20 c. c. \approx 1 decigramme.

These solutions should be kept *separate* until required for use, as the quality of the *mixture* rapidly deteriorates.

In the preparation of the foregoing test-solutions, it is important that the chemicals employed be of the purest character, and before weighing should be free from adhering moisture. To secure the greatest accuracy, the solutions should be titrated as soon as made. If, for instance, it is desired to determine the exact chemical strength of the mercurial solution, we carefully weigh half a grain of pure urea and dissolve it in a little water. The burette

is now filled to the 0 mark with the mercurial solution and the titration is performed as directed in the analysis for urea, (p. 38,) omitting, however, the baryta solution. If, upon the termination of the analysis, it is found that 100 grains of solution have been employed to effect the desired reaction, the solution possesses, of course, the required strength. If less than 100 grains of solution effected the final result, the solution is too strong and must be diluted; if more than 100 grains were required, it is too weak, and more nitrate of mercury must be added.

The exact amount of water or of the salt required to standardize the solution may be ascertained by the rule of three. The other solutions may, in like manner, be titrated with definite quantities of their appropriate reagents.

The solutions of chloride of iron and nitrate of uranium should be titrated with phosphate of soda. The solutions of chloride of barium and ferrocyanide of potassium can not be conveniently titrated.

CHAPTER IV.

COLOR, REACTION, SPECIFIC GRAVITY, AND ESTIMATION OF SOLIDS.

Color.—The color of the urine, as is well known, varies from a pale yellow or straw color to a dark brown or even blackish tint. The depth of color, except when produced by blood or some accidental pigment, depends upon the presence in greater or less quantity of certain coloring matters, concerning the nature of which there has been much dispute. Harley,* who has given a great deal of attention to this subject, and who has promulgated the most plausible view concerning the nature of the urine pigment, believes that it is a direct derivative of the coloring matter of the blood, and has named it Urohæmatin.†

* Harley. The Urine and its Derangements. London, 1872.

† As these pages are passing through the press, we have met with spectroscopic evidence corroborating the view that the urine pigment is

Urohæmatin is probably present in every specimen of urine, but does not exist entirely in a free state, being combined to a greater or less extent with certain bases, from which it may be freed by the addition of nitric or hydrochloric acids. In estimating the quantity of urohæmatin contained in a specimen of urine, it is important [Harley] to add a small quantity of one of the acids mentioned, as the appearance of the urine before the use of the reagent is no guide to the amount of pigment contained—a pale urine often yielding a higher tint, upon the addition of the acid, than another specimen which was originally darker.

When it is desired to record the tint of a specimen of urine, before or after the addition of acid,

a derivative of the coloring matter of the blood, by the discovery, in a solution of decomposing hæmoglobin, of a broad but distinct band of absorption between the Fraunhofer lines *b* and *F*. This line appears to be identical in position and character with the band discovered by Jaffe (*Virchow's Archiv*, B. 47) in Urine and in solutions of Urobilin. In the solution of hæmoglobin referred to, the new band was accompanied by the two oxygen blood bands, (between *D* and *E*), and also by the methæmoglobin band, (between *C* and *D*.) This association gave a four-banded blood spectrum, differing from any that we can find on record, and the composite nature of which was evident.

the Color-table of Vogel * will afford a useful and now almost universal standard of comparison.

Reaction.—The reaction of normal urine is usually acid, though sometimes neutral or even faintly alkaline. It is to be ascertained by the use of Litmus paper. If the urine be acid, the blue paper is reddened; but, if alkaline, the blue color is restored to previously reddened paper. If neutral, neither the blue nor the red papers change their colors. The *degree* of acidity or alkalinity may be ascertained in the following manner:

Prepare a solution containing 10 gr. of pure hydrate of soda to 1000 grains of water. Each grain of this solution will consequently contain .01 gr. of soda. Fill the burette to the 0 mark with the solution of soda, and bring under it a measured quantity of acid urine in a small beaker. The soda solution is now added to the urine in small quantities at a time, and thoroughly mingled with it, and a piece of blue litmus paper is dipped into the mixture after each addition. As long as the paper is red-

* Vogel. Farbentabelle für den Urin.

dened, it is necessary to continue the addition of the alkaline fluid; but as soon as the mixture fails to affect the paper, the operation is concluded and an examination of the burette will indicate the number of grains of solution employed to neutralize the urine under examination. If 25 grains of solution have been used, it will indicate that .25 gr. of soda have been required to effect the neutralization of the quantity of urine employed. If the same volume of urine, say one ounce, be used on every occasion, the number on the burette may be simply recorded as the index of acidity. Before the result, however, is recorded, the mixture should be tested with reddened paper. If the paper be unchanged, the analysis is terminated; but if, on the other hand, the mixture be decidedly alkaline in reaction, the experiment must be repeated with greater care toward the end of the process.

If the urine be *alkaline*, and we desire to ascertain the degree of its alkalinity, we prepare a solution containing 15.75 grs. of pure oxalic acid to 1000 grains of water. This solution is exactly neutralized

by an equal volume of the soda solution given above.

Specific Gravity.—The specific gravity of a specimen of urine may be ascertained by either of the following methods:

I. *By means of the Urinometer.*—To use this instrument, pour a sufficient quantity of urine into the jar, and introduce the urinometer. The figures upon the stem which are opposite the level of the fluid indicate the specific gravity.



Fig. 11.

The standard temperature at which the specific gravity of a fluid is to be ascertained is 60 deg. F.; but, as it is not always convenient to bring the urine to the required temperature, the following table of corrections* for the glass urinometer will be found of service.

Example.—If the temperature of the urine at the time of observation is 75 deg. F., and the urinometer

* Bird. Urinary Deposits, etc., Am. Ed. p. 70.

indicates a sp. gr. of 1018, the corrected or true sp. gr. of the specimen will be $1018 + 1.4 = 1019.4$.

T.	No. to be added to the indication.	T.	No. to be added to the indication.	T.	No. to be added to the indication.
60	.00	69	.80	78	1.70
61	.08	70	.90	79	1.80
62	.16	71	1.00	80	1.90
63	.24	72	1.10	81	2.00
64	.32	73	1.20	82	2.10
65	.40	74	1.30	83	2.20
66	.50	75	1.40	84	2.30
67	.60	76	1.50	85	2.40
68	.70	77	1.60	86	2.50

II. *By means of the Bottle and Balance.*—The sp. gr. of a specimen of urine may be ascertained with the greatest accuracy by means of a bottle and a good balance. A bottle made for the purpose, Fig. 12, and capable of holding exactly 1000 grains of distilled water, is counterpoised upon a balance, and afterward filled with urine. The bottle is now returned to the balance and the weight of its contents ascertained. This weight expressed in grains will be the index of its specific gravity; if, instead of

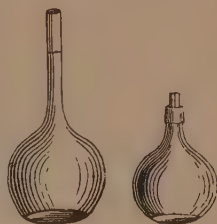


Fig. 12.

a 1000-grain bottle, one holding 500 grains be used, the sp. gr. will be obtained by multiplying the weight of its contents by 2.

Example.—Suppose the 500-grain bottle weighs x grains. Filled with distilled water, it weighs $x + 500$ grains. Filled with urine, it may weigh $x + 513$ grains, which, multiplied by 2, gives 1026 as the sp. gr.

It will save time to have always at hand an exact metallic counterpoise of the empty bottle.

ESTIMATION OF SOLIDS.

The respective proportions of water and solids in any specimen of urine may be ascertained in the following manner:

Take a small platinum or good porcelain capsule, the weight of which is known, and introduce into it a weighed amount of urine. Place the capsule and contents upon the water-bath and evaporate to dryness. When dry, it is again weighed. The loss in weight gives the amount of water, and the difference between the weight and that of the

empty capsule gives the weight of the solids. If the capsule containing the dry residue be now exposed to the naked flame of an alcohol lamp or Bunsen burner, the organic portions will be destroyed—known by the contents of the capsule first blackening, and then becoming of a whitish color. The weight of this incinerated residue enables us to determine the respective weights of the organic and inorganic ingredients of the urine.

Example.—Two fluid drachms of urine,

whose sp. gr. was 1025.5, weighed.. 116.82 gr.

After evaporation to dryness, the residue

weighed..... 6.42 gr.

After incineration the ash weighed..... 2.14 gr.

RESULT.

Water in two fluid drachms..... 110.40 gr.

Organic substances..... 4.28 gr.

Fixed salts..... 2.14 gr.

Multiplying these figures by 4, will give the proportions of water, organic and inorganic constituents per fluid ounce.

CHAPTER V.

ESTIMATION OF NORMAL CONSTITUENTS.

UREA.

THE presence of Urea in a given specimen of urine being assumed, (its entire absence rarely if ever occurring,) the sole object of the analysis will be to ascertain the proportion in which it exists. Several methods have been devised for this purpose, but those of Davey and of Liebig are the most convenient and generally applicable, although not as absolutely correct as some others.

Davey's Method.—This method is founded upon the fact that Urea is very readily decomposed by the hypochlorites of soda, potash, or lime, and its constituent nitrogen is evolved in a gaseous state. From the volume of gas evolved, the amount of urea is

calculated. The process is described by Thudichum* substantially as follows:

Obtain a strong glass tube twelve or fourteen inches long, closed at one end and with its open extremity ground smooth, and having a bore not larger than can be conveniently covered with the finger. The tube should hold from two to three cubic inches, each divided into tenths and hundredths by graduations on the glass. When used, the tube is filled about a third full of mercury, after which add half a fluid drachm of the urine to be examined; then holding the tube in one hand near its open extremity, with the thumb in readiness to cover the aperture, fill it completely with a solution of the hypochlorite of soda, taking care not to overflow it; cover instantly and tightly with the thumb and invert once or twice to thoroughly mix the urine with the soda solution.

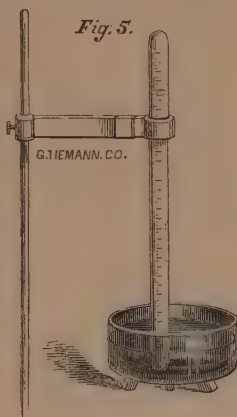


Fig. 13.

* Thudichum, Pathology of the Urine. London, 1858.

The tube is then to be opened beneath the surface of a suitable vessel containing a saturated solution of common salt. The tube is now to be supported in a vertical position. As soon as the tube is placed in position, the mercury flows out and the salt solution takes its place; the hypochlorite, however, being lighter than the solution of salt, will remain in the upper part of the tube. The moment the hypochlorite comes in contact with urine, a rapid disengagement of nitrogen gas takes place, which collects at the upper part of the tube. In from six to twelve hours, the decomposition of the urea will be complete, and the volume of nitrogen obtained is to be observed. Each cubic inch of gas obtained in this way corresponds to .645 of a grain of urea.

If the analysis be performed in the manner above described, the following table, constructed by Prof. Flint,* will materially assist the calculation of the amount of urea per fluid ounce of urine.

* Flint, Chemical Examination of Urine.

Table showing the Quantity of Urea in Grains, per Fluid Ounce of Urine, corresponding to the Divisions of the Urea Tube, when half a Fluid Drachm of Urine has been used for Analysis.

Divisions of a Cubic Inch.	Grains of Urea per Fluid Ounce.	Divisions of a Cubic Inch.	Grains of Urea per Fluid Ounce.	Divisions of a Cubic Inch.	Grains of Urea per Fluid Ounce.
0·10	1·032	0·74	7·637	1·38	14·241
0·12	1·238	0·76	7·843	1·40	14·448
0·14	1·444	0·78	8·049	1·42	14·654
0·16	1·651	0·80	8·256	1·44	14·860
0·18	1·857	0·82	8·462	1·46	15·067
0·20	2·064	0·94	8·669	1·48	15·273
0·22	2·270	0·86	8·875	1·50	15·480
0·24	2·476	0·88	9·081	1·52	15·686
0·26	2·683	0·90	9·288	1·54	15·893
0·28	2·889	0·92	9·494	1·56	16·099
0·30	3·096	0·94	9·701	1·58	16·305
0·32	3·302	0·96	9·907	1·60	16·512
0·34	3·508	0·98	10·113	1·62	16·718
0·36	3·715	1·00	10·320	1·64	16·925
0·38	3·921	1·02	10·526	1·66	17·131
0·40	4·128	1·04	10·733	1·68	17·337
0·42	4·334	1·06	10·939	1·70	17·544
0·44	4·540	1·08	11·145	1·72	17·750
0·46	4·747	1·10	11·352	1·74	17·957
0·48	4·953	1·12	11·558	1·76	18·163
0·50	5·160	1·14	11·764	1·78	18·369
0·52	5·366	1·16	11·971	1·80	18·576
0·54	5·573	1·18	12·177	1·82	18·782
0·56	5·779	1·20	12·384	1·84	18·989
0·58	5·985	1·22	12·590	1·86	19·195
0·60	6·192	1·24	12·796	1·88	19·401
0·62	6·398	1·26	13·003	1·90	19·608
0·64	6·605	1·28	13·209	1·92	19·814
0·66	6·811	1·30	13·416	1·94	20·021
0·68	7·017	1·32	13·622	1·96	20·227
0·70	7·224	1·34	13·828	1·98	20·433
0·72	7·430	1·36	14·035	2·00	20·640

For clinical purposes, the above method is in general sufficiently accurate, but if greater exactness is desired, corrections for temperature and barometric

pressure must be made. This may be readily effected by the aid of the following formula:

$$V' = \frac{V(H-f)}{(1+0.00367\ t)\ 760},$$

in which V' represents the corrected volume.

V , the volume of gas observed.

H , the height of the barometer in millimetres.

f , the tension of the vapor of the water at

t , the temperature by the Centigrade scale at which the gas is measured.

The following table by Regnault gives the value of f , and also of the denominator $(1+0.00367\ t)\ 760$, for all temperatures between 0° and $30^{\circ}\ C$.

C. $^{\circ}$	Value of ($1+0.00367\ t$) $\times 760$.	Value of f .	C. $^{\circ}$	Value of ($1+0.00367\ t$) $\times 760$.	Value of f .
1	762.8	4.9	16	804.6	13.5
2	765.6	5.3	17	807.4	14.4
3	768.4	5.7	18	810.2	15.3
4	771.2	6.1	19	813.0	16.3
5	773.9	6.5	20	815.8	17.4
6	776.7	7.0	21	818.6	18.5
7	779.5	7.5	22	821.4	19.7
8	782.3	8.0	23	824.1	20.9
9	785.1	8.6	24	826.9	22.2
10	787.9	9.2	25	829.7	23.6
11	790.7	9.8	26	832.5	25.0
12	793.5	10.5	27	835.3	26.5
13	796.3	11.2	28	838.1	28.1
14	799.1	11.9	29	840.9	29.8
15	801.8	12.7	30	843.7	31.5

Example.—Let $V = .42$ cub. in. of nitrogen gas observed at 20° C., and H a barometric pressure of 758 mm.,* then,

$$V' = \frac{.42 (758 - 17.4)}{815.8} = .38.$$

From this it will be seen that the difference between the observed and the corrected volume, at the temperature and pressure taken (about 68° F., and 29.84 inches,) involves an error of over ten per cent. If the temperature be higher or the pressure less—not unusual conditions—the error will be still greater.

A serious inconvenience connected with the performance of Davey's process arises from the variability in the decomposing power of different preparations of hypochlorite solution. The difficulty of obtaining solutions of requisite and uniform power led me for a time to abandon this method of analysis in favor of Liebig's. Dr. George B. Fowler,† how-

* If the temperature and pressure be observed with a Fahrenheit thermometer and a barometer graduated in inches, the reductions can easily be effected by tables in the Appendix.

† New-York Med. Jour., Aug. 1872.

ever, has ascertained that the *liq. sodæ chlorinatæ* of Squibb possesses the requisite qualifications, and my own more recent experience with it confirms his conclusions.

Liebig's Method.—This method takes advantage of the fact that Urea will combine with the oxide of mercury, and hence all that is necessary is to obtain a standard solution of mercury, with which to titrate the solution of Urea, and also an indicator by means of which to detect the point when all the Urea has entered into combination with the mercury and the latter slightly predominates. This indicator is a sol. of carbonate of soda. Before, however, urine can be submitted to titration with a mercurial solution, it is necessary to remove the phosphoric acid. This is effected by means of the “baryta solution,” (p. 19.)

The analytical process may be conducted as follows :

Mix a convenient quantity of urine with *exactly* half its volume of the baryta solution, and pour the mixture upon a dry filter. When a sufficient quantity

of clear fluid has passed through, transfer by means of a pipette one fluid drachm of it to a beaker, and add a little distilled water to increase the bulk of the fluid, and bring it under a burette filled to the 0 mark, with the standard solution of mercuric nitrate, (p. 19.) Deliver the test solution into the beaker as long as a precipitate is distinctly seen to form. Have ready prepared a slip of black glass, upon which have been placed a few separate drops of a solution of carbonate of soda. A drop of the mixture in the beaker is to be brought from time to time in contact with the soda solution upon the glass. If the color remain white, free urea is still present; but when it becomes yellow, the addition of the mercuric solution is to be discontinued, and the number of grains of S.S. employed is to be ascertained by looking at the burette. This number, multiplied by 12 and divided by 200, will give the number of grains of Urea per fluid ounce of urine.

The above process is quite accurate, if allowance be made for chloride of sodium, which also decomposes the mercuric solution, and does so in *advance*

of the reaction which takes place between the Urea and the mercury. The mercurial compound, (chloride of mercury,) however, is soluble, and does not give rise to any precipitate, the precipitate due to the union of the Urea and mercury not forming until all the chloride of sodium has been decomposed. This obliges us to watch for the first indication of a precipitate, and to deduct from the final result the number of grains of S.S. that have been used before the precipitate occurs.*

This prior reaction between the mercury and the chloride enables us also to estimate the quantity of chloride of sodium; for, if the number of grains of S.S. used, before the precipitation of the Urea, be divided by 4, the quotient will *very nearly* represent the number of grains of chloride of sodium per fluid ounce of urine.†

Neither sugar nor albumen interfere with the performance of Davey's process; but in using Liebig's

* It is extremely important that the mercuric solution should be free from excess of acid, or from metallic contamination, as bismuth, silver, or lead may give a cloudiness which will embarrass the observation.

† The exact divisor is 4.15.

method, albumen, if present, should be separated before titration.

The two processes above given are simple and easily performed, and for most clinical purposes sufficiently accurate. For more exact determinations, the procedures of Millon, Grehant, or Boymond,* are to be preferred; but, as they are tedious and complicated, and require somewhat elaborate apparatus, their consideration is omitted.

URIC ACID.

This acid usually exists in the urine, in combination with certain bases from which it may be separated by any of the strong acids. The one usually employed for this purpose is hydrochloric. If to a given quantity of urine about 5 per cent of its volume of hydrochloric acid be added, and the mixture be set aside in a cold place for twenty-four hours, the Uric acid will be deposited upon the bottom and sides of the vessel as reddish brown crystals. Pure Uric acid is white, but the color of the crystals usually obtained

* Boymond. *L'Urée*, etc. Paris, 1872.

is due to the precipitation with them of a certain portion of the coloring matter of the urine, in a state of intimate adherence.

If the crystals be now separated from the fluid by filtration or decantation, they may be recognized as Uric acid by their microscopical appearance, and by the following tests: The crystals of Uric acid disappear upon the addition of *liq. potassæ*, and may be caused to reappear by the further addition of hydrochloric acid in excess. If brought in contact with nitric acid, the crystals dissolve with slight effervescence; and if the acid be driven off by the application of a *gentle* heat, and ammonia added, a bright purple color will appear. This is known as the Murexid test.

The *quantitative* determination of Uric acid involves its separation by the means given. It must then be weighed, or else its amount ascertained by titration with a standard solution of *permanganate of potash*. The former of these methods is preferred by most authorities. The analysis is performed as follows: Take four, six, or eight ounces of

filtered urine carefully measured; add from two to four drachms of hydrochloric acid, and set the mixture in a cool place for 24 hours. When precipitation is complete, have ready a small filter of Swedish paper which has been thoroughly dried in the water-oven, and afterward weighed.* The filter is now adjusted to the funnel and the urine containing the precipitated acid is brought upon it, care being taken that no crystals are left clinging to the vessel. After the whole of the urine has passed through the filter, the precipitate is to be thoroughly washed with a wash-bottle, first with dilute hydrochloric acid, and afterward with distilled water. When the last water has passed through, the filter and contents are removed to the water-oven and thoroughly dried; when dry, it is to be weighed, and the original weight of the filter deducted. The remainder, of course, represents the quantity of Uric acid in the volume of urine employed.

* The filter may be considered dry when two successive weighings show no loss of weight.

The following modification of this method is found in Neubauer and Vogel.*

A certain quantity of urine is "measured off by the pipette, introduced into a porcelain basin, and evaporated to the consistence of a syrup in a water-bath. This residue is treated with small quantities of strong spirits of wine of 0.83 specific gravity so long as the alcohol takes up any of it. The residue is well stirred up with the alcohol, the insoluble matter allowed to subside, and the spirit more or less turbid is passed through a filter previously dried and weighed. (The border of the basin is smeared with a little grease to prevent the running down of any drops.) The extract remaining in the basin is again several times treated in the same way with the spirit of wine, and dilute hydrochloric acid (1 part hydrochloric acid and 6 parts water) then poured upon it. The residue is now placed upon the same filter, washed first of all with dilute hydrochloric acid, and then with water, and dried

* N. and V. Analysis of the Urine. Sydenham Translation. London, 1863. P. 218.

and weighed." (This process is omitted in the last German edition of Neubauer and Vogel.*)

Volumetric Estimation of Uric Acid.—The volumetric method advocated by Sutton† and others may be performed as follows: Take a measured quantity of urine in a beaker and precipitate the Uric acid by means of HCl. After twenty-four hours, remove the supernatant fluid by decantation and wash the crystals in the beaker with cold distilled water. The crystals are then dissolved in a small quantity of pure solution of potash and two or three ounces of distilled water, strongly acidified with sulphuric acid added. The beaker is then brought under the burette filled to the 0 mark with the S.S. of permanganate of potash, (p. 20.) Upon the addition of a small quantity of the permanganate to the fluid in the beaker, its color is immediately destroyed. This destruction of the color of the permanganate continues upon each addition of the S.S. until all of the Uric acid has been exhausted. When this occurs, a faint pinkish

* N. and V. Analyse des Harns. 6te Auflage, 1872.

† Sutton. Handbook of Volumetric Analysis. London, 1871, p. 219.

color appears, not removed by stirring, and indicates the termination of the analysis. Every grain of S.S. used represents $\frac{1}{200}$ of a grain of Uric acid.

Referring to this process, Sutton says: "This method is not absolutely correct, owing to the fact that with the Uric acid there is always precipitated a certain amount of coloring matter of the urine, which destroys the permanganate equally with the Uric acid. The method by weighing is, however, open to the same objection, besides being troublesome, so that no advantage is gained by the latter plan."

In connection with each of the three processes given above there is a common source of error, which should be noted and the necessary correction made. The error is due to a very slight solubility of Uric acid in acidulated fluid. This solubility amounts to about .018 grs. of Uric acid per fluid ounce of acid solution; we must therefore consider how many ounces of urine and how many of acidulated fluid have been employed, and for each ounce add the fraction given. For instance, if we have precipitated

the Uric acid from four ounces of urine, washed it with twelve ounces of dilute HCl., and found the amount of Uric acid to be 1.40 grains, we must add to this sixteen times the fraction, ($.018 \times 16 = .288$), which will give us 1.688 grains as the correct amount.

PHOSPHORIC ACID.

The quantitative determination of Phosphoric acid in urine may be effected by either of the two following processes. The first is that of Liebig, and is accomplished by means of a standard solution of chloride of iron. It may be performed as follows:

Measure with the pipette two fluid drachms of urine into a small beaker; add about half a drachm of the acid solution of the acetate of soda, (p. 20,) and also a little distilled water to increase the volume of fluid. Warm the mixture a few minutes in the water-bath or over a spirit-lamp, and bring it under a burette filled to the 0 mark with the S.S. of chloride of iron, (p. 20,) and place a few separate drops of a dilute solution of ferrocyanide of potas-

sium upon a piece of white glass or in a saucer. Add the solution in the burette to the mixture in the beaker, in small quantities at a time, and after each addition stir well with a glass rod, and bring a drop from the beaker in contact with one of the drops of ferrocyanide. If no change of color be produced, continue the addition of the S.S. until, upon testing, a blue color appears upon contact of a drop from the beaker with a drop of the ferrocyanide. This indicates that all the Phosphoric acid has been appropriated by the iron, and that the latter is in excess, and terminates the analysis. The number of grains of S.S. used is now ascertained, and this number, divided by 50, will give the number of grains of Phosphoric acid per fluid ounce of urine. This process is recommended by some good authorities, and, for that reason, has been given in detail. Thudichum,* however, says, "If the amount of phosphoric acid is small, the above method is liable to give rise to an error amounting, in the hands of a good operator, to 10 per cent, according to Neubauer. This error, according to

* Op. cit. p. 185.

Vogel, may amount to 20 or 30 per cent, if a less conscientious operator assumes blue spots of different intensities as the completion of his analyses, or if he allows some time to elapse before trying for the blue spot." We can only add that this test has been to ourselves the source of more uncertainty and annoyance than any other connected with volumetric analysis of urine, and we have, for some time, given it up in favor of the method next to be mentioned.*

Uranium Process.—This method appears to have been devised, about the same time, by three independent experimenters, Sutton, Neubauer, and Pinus, and depends upon the fact that Phosphoric acid forms a very definite and stable compound with the oxide of uranium. For preparing the standard solutions, either the acetate or the nitrate of uranium may be employed. The latter, however, is to be preferred, because it is more easily obtained pure, and its solution is less likely to spoil by keeping than that of the acetate. Ferrocyanide of potas-

* This chloride of iron process is omitted in the last edition of Neubauer and Vogel, although given in some of the earlier editions.

sium, as in the previous process, serves as an indicator of the conclusion of the analysis, striking a distinct brown color when in contact with the uranium solution. The acetate of soda solution is as requisite in this test as in the last.

Measure, as before, two fluid drachms of urine into a beaker; add half a drachm of acetate of soda solution and a little water, and warm. Have prepared a slip of white glass with several separate drops of ferrocyanide solution. When the mixture is warm, bring it under a burette filled to the 0 mark with the S.S. of nitrate of uranium, (p. 20,) and titrate with the usual precautions. When a drop from the beaker, brought in contact with a drop of the ferrocyanide, strikes a brown color, the analysis is terminated; and the number of grains of S.S. used, divided by 50, will give the number of grains of Phosphoric acid per fluid ounce of urine.

(*Approximative Analysis*.—Marais* has suggested a very simple and convenient method of approximative analysis of several of the urinary constituents. He introduces a measured quantity of urine into a graduated tube, adds the suitable re-

* Marais's *L'Analyse des Urines*. Paris. 1873.

agent, and leaves the tube in a vertical position for twenty-four hours for the precipitate to subside. At the end of this time, he ascertains the volume of the precipitate, and from it estimates the quantity of the substance whose determination is sought. He has applied this method to the estimation of the earthy phosphates, of sulphuric acid, and of chloride of sodium. We have extended the application of the process, and have had constructed some tubes properly graduated to permit of its convenient employment. The tubes have the form shown in Fig. 14. They are $8\frac{1}{2}$ inches in length, exclusive of the foot, and $\frac{5}{8}$ of an inch in diameter inside. They are graduated in fifths of a cubic centimetre from the bottom up to 15 c.c. Above these graduations is a line indicating the level of one fluid ounce, (456 grs.) It is also convenient to have a 25 c.c. line for the benefit of those using the metric system, and to facilitate percentage calculations. We have had the tube graduated in c.c. for sake of convenience, and because it is strictly a measure of volume.)

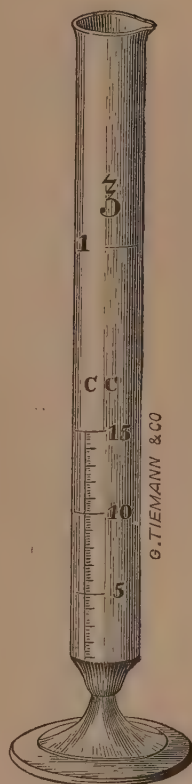


Fig. 14.

Approximative Analysis of Phosphoric Acid.—

Fill the tube to the ounce-mark with filtered (to avoid deposits of mucus, pus, urates, etc.) urine; add two drachms of acetate of soda solution, and afterward, an excess of a solution of nitrate of uranium,

(one to ten;) mix well, and set aside for twenty-four hours. At the end of that time, the number of cubic centimetres of precipitate is to be noted. The daily variations of phosphate in any particular case can thus be easily determined and recorded. We have made a number of trials to ascertain the amount of Phosphoric acid in each c.c. of precipitate obtained in the manner above described, and we have found that every .2 c.c. was \approx .014 gr. of Phosphoric acid.* The amount of Phosphoric acid, per fluid ounce, of the specimen can then be readily calculated.

Approximative Analysis of the Earthy Phosphates.

—Introduce, as before, one ounce of filtered urine into the tube, add an excess of strong *liq. ammonia*, mix, and set aside for twenty-four hours. At the end of that time note the amount of precipitate. Marais has found that .2 c.c. of precipitate \approx .004 grammes (about .06 grains) of Earthy Phosphates.

* We do not consider these figures entitled to much confidence as yet, from the fact that the tubes used were graduated in this country, and are not very accurate. Messrs. Tiemann & Co. have, however, recently had some made to order in Berlin with correct graduations.

SULPHURIC ACID.

The method almost universally adopted for the quantitative determination of Sulphuric acid in urine, is the one by means of the chloride of barium. It may be performed as follows:

With a pipette introduce two fluid drachms of urine into a small beaker, add about half an ounce of distilled water and a little hydrochloric acid, and place the mixture in the water-bath, or hold it over a spirit-lamp until it becomes hot. Fill the burette to the 0 mark with the standard solution of chloride of barium, (p. 21,) and bring the beaker under it. Permit a small portion of the test solution to drop into the beaker, and a precipitate of the sulphate of baryta will immediately form, and will gradually subside. Continue the addition of the S.S. until no more precipitate appears to form. Then set aside until there appears a stratum of clear fluid above the precipitate. When this is found, add a drop or two more of the test solution. If this induces a fresh precipitate, continue the cautious addition of the S.S. as before; but if *no* precipitate forms, bring

a drop of the clear fluid in contact with a drop of a solution of the sulphate of soda. If now a dense white precipitate appears, it shows that the chloride has been added to the urine in too great excess, and the analysis must be repeated with more care toward the end. The number of grains of S.S. finally determined upon as necessary for the precipitation of all the Sulphuric acid, divided by 50, will give the number of grains of Sulphuric acid per fluid ounce of the specimen.

Approximative Analysis of Sulphuric Acid.—Introduce, as before, one ounce of filtered urine into the tube, Fig. 12; acidify with HCl. and add an excess of a solution of chloride of barium, (1 to 10,) and set aside for twenty-four hours. Each .2 c.c. of precipitate will correspond, according to Marais, to .343 grammes (about 5.29 grains) of anhydrous Sulphuric acid. Owing to the small amount of Sulphuric acid in the urine and the dense character of the precipitate of sulphate of baryta, this method will not permit of its being determined with any accuracy unless a much narrower tube and one capable of holding at

least two or three ounces be employed. The process by titration, therefore, is to be decidedly preferred.

CHLORIDE OF SODIUM.

The volumetric estimation of the Chlorides in urine is usually effected by the precipitation of the chlorine in combination with silver, by means of a standard solution of nitrate of silver. The method of analysis generally employed is that of Mohr, and takes advantage of the fact, that the chromate of potash, which under ordinary circumstances gives with the nitrate of silver a bright-red precipitate of chromate of silver, fails to do so in the presence of a neutral or slightly alkaline solution of the Chloride of sodium. In other words, the nitrate of silver first decomposes the Chloride of sodium, and forms a chloride of silver, and continues to do so until all of the chlorine has been appropriated. When this has occurred, the nitrate of silver then acts upon the chromate of potash and gives rise to a permanent red precipitate.

The analysis may be performed as follows :

Introduce *one* fluid drachm of filtered urine into a small beaker; add to it half an ounce or more of distilled water, together with two or three drops of a saturated solution of chromate of potash. Test the reaction of the mixture, and render it neutral or *faintly* alkaline by the addition of carbonate of soda or nitric acid, as may be necessary. Bring the beaker under the burette filled to the 0 mark with the S.S. of nitrate of silver, (p. 21.) The addition of a few drops of the test solution to the contents of the beaker may be followed by the momentary appearance of a red precipitate, which disappears upon stirring. Continue the addition of the silver solution in small quantities at a time until the last addition is followed by a *permanent* red precipitate coloring the mixture in the beaker. This terminates the analysis. Note the number of grains of S.S. used, and divide this number by 25, and you will have the number of grains of Chloride of Sodium per fluid ounce of urine.

Observation.—The lighter the color of the mixture in the beaker, the more readily will the first

traces of the *permanent* precipitate be detected, and the accuracy of the analysis thereby enhanced. It is therefore desirable, if possible, to decolorize the urine. We cannot, in this analysis, avail ourselves of the usual decolorizing agents, acetate of lead or animal charcoal, but must employ other means. Two have been suggested. *First*. Measure the drachm of urine into a porcelain capsule, and add 10 grains of pure powdered nitrate of potash.* Evaporate the mixture to dryness, and then gradually heat the residue over the naked flame until it becomes white. When cool, dissolve the incinerated residue in about an ounce of distilled water. The reaction of this solution will be distinctly alkaline, and it must be *nearly* neutralized by the cautious addition of nitric acid. The chromate of potash is then added, and the subsequent steps of the operation conducted in the usual manner.

Second. Pibram† adds to the urine a little per-

* The nitrate of potash should be tested for chlorides before use, as that sold for pure frequently contains an appreciable quantity of chlorine.

† Vierteljahrsch. für pract. Heilkunde.

manganate of potash in solution, and brings the mixture nearly to the boiling-point. This gives a brownish, flocculent precipitate, which is removed by filtration, and the filtrate is then subjected to titration in the usual way.

Approximative Method.—Fill the graduated tube to the ounce mark with filtered urine, and strongly acidify with nitric acid. Then add an excess of a solution of nitrate of silver, (1 to 10,) and set aside for twenty-four hours. At the end of this time note the volume of precipitate. Marais states that each .2 c.c. of precipitate will correspond to .0124 grammes (about .19 grains) of Chloride of Sodium. The urine is strongly acidified in this method, because, otherwise, the nitrate of silver would, after decomposing the chlorides, next attack the phosphates, and produce a precipitate of the phosphate of silver, which would, of course, lead to erroneous conclusions.

CHAPTER VI.

DETECTION AND ESTIMATION OF ABNORMAL CONSTITUENTS OF URINE.

HAVING finished with those normal ingredients of the urine which most frequently concern the physician, we turn to a consideration of certain other substances formed within the body, but whose appearance in the urine is to be regarded as an indication of disease. The most important of these are albumen, sugar, and certain of the biliary constituents.

ALBUMEN.

Various methods have been proposed for the detection of this substance in urine, but the simplest and most reliable is the test by *Heat* and *Nitric acid*.

Ordinary clear and transparent urine, when boiled in a test-tube, may, under two different conditions, present a turbid appearance. If the urine be *alka-*

line, the turbidity will probably be due to the *precipitation* of the earthy phosphates, which are less soluble in a warm than in a cold fluid. The addition of a little nitric acid will dissolve this precipitate, and, if no albumen be present, the fluid remains clear. On the other hand, if the urine be *acid* when boiled, turbidity will occur, provided albumen be present in appreciable quantity. In this case, the turbidity is due to the *coagulation* of the albumen, and will not disappear upon the *subsequent* addition of nitric acid, unless the latter be in great excess.

The presence, however, of a small quantity of nitric acid in the mixture, *previous* to boiling, may prevent the customary reaction. Upon this point Beale says,* "*If a few drops of nitric acid be added to a portion of albuminous urine in a test-tube, and the mixture subsequently boiled, no precipitate will be produced.*" This peculiar reaction is supposed to be due to the decomposition of the phosphates of the urine by the nitric acid, the free phosphoric acid

*Beale. Kidney Diseases and Urinary Deposits. London, 1870.

serving to keep the albumen in solution, in spite of the application of heat.

A number of other tests for albumen have been proposed, as more delicate than the one just given; many of these, however, are unreliable, and one of them, at least, is utterly fallacious. We will notice it here, in order to put the reader on his guard against employing it, as we know of its having been extensively used in one of the hospitals of this city.

Fallacy of the so-called Alcohol-test for Albumen.

—It is stated that if alcohol be added to urine in a test-tube containing a trace of albumen not detectible by heat or nitric acid, its presence will be evidenced by the appearance of a milky line at the junction of the alcohol with the urine. Harley,* who has observed this reaction, states that the white precipitate is albumen, but that it is not indicative of Bright's disease, as it can be found in normal urine. In other words, that it is a different kind of albumen from the one produced by disease of the kidneys, and that it is a normal constituent of urine.

* Harley. Op. cit. p. 288.

He further states that it can be most readily obtained by the use of absolute alcohol. Desiring to test the accuracy of these statements, we made the following, among other observations: A test-tube was about half-filled with filtered urine, supposed to be healthy, and to this was added a drachm or so of absolute alcohol. The precipitate immediately formed, but was redissolved by agitation. The tube was then filled to the top with more of the alcohol, and a copious precipitate appeared. It was set aside for twenty-four hours, at the end of which time the precipitate had subsided to the bottom. A portion of the precipitate was now removed with a pipette, and examined microscopically. The material under examination was found to consist of three different substances: first, abundant and large crystals of oxalate of lime; second, very large prismatic crystals resembling and probably consisting of ammonio-magnesian phosphate;* and third, a granular amor-

*The early appearance of the triple phosphate would be difficult of explanation, were it not for the observations of Drs. Tidy and Woodman, (*Proceed. Roy. Soc.* 1872,) who have shown that ammonia is a constant constituent of fresh, healthy urine.

phous material having no peculiar or distinctive characters. (It may be stated that another tube filled with the same urine, but without the addition of the alcohol, presented, after twenty-four hours, no trace of crystalline deposit, and none was found on microscopical examination.) The supernatant fluid was now decanted, and the deposit washed several times with cold absolute alcohol, without much apparent diminution of its bulk. The alcohol was then removed, and a little distilled water added. This *dissolved* most of the precipitate. The solution was then thrown upon a filter. The addition of an excess of alcohol to the filtrate again caused a white precipitate, which, upon microscopical examination, was found to consist entirely of the amorphous material already alluded to, no crystalline forms being present. The effect of various reagents was then tried—among others, acetic acid, oxalic acid in alcohol, and nitric acid. All of these acids dissolved the granular matter; but there appeared, in its stead, a vast number of small crystals, whose forms were peculiar to the acid employed, and were different from any

we had previously encountered in urine. An examination of the optical properties of these crystals by polarized light leads to the suspicion that the amorphous material is not a simple substance, but a mixture of two or more. What this substance or these substances are, we are as yet unable to say; but certainly some of the reactions noticed could not be produced by any form of albumen with which we are familiar.

QUANTITATIVE DETERMINATION OF ALBUMEN.

It is often of interest, and sometimes of importance, to ascertain the amount of albumen in a specimen of urine under examination. This may be determined, with more or less accuracy, by one of the following methods:

I. *Weighing upon a Wet Filter*.—Select a suitable filter, place it in a funnel, and wet it thoroughly with water. When the water ceases to drop, remove it from the funnel and weigh it, and afterward replace it in the funnel. Next coagulate the albumen in a measured volume of urine, by means of acetic

acid and heat, and pour it upon the filter. When the fluid has all passed through, and the filter ceases to drip, remove it from the funnel, and again weigh. The increase in weight of course represents the amount of wet coagulated albumen in the urine employed. This is roughly approximate.

II. *Weighing upon a Dry Filter*.—Carefully dry a small filter, and, after weighing, place it in a funnel. Pour upon it the coagulated albumen from a known volume of urine, and after the fluid has passed through, wash carefully with acidulated, and afterward with pure water. Remove the filter and contents to the water-oven, and dry it thoroughly. When dry, again weigh; the increase will represent the amount of dried coagulated albumen in the urine employed.

III. *With a Graduated Tube*.—Coagulate the albumen in an ounce of urine, and pour the mixture into one of the graduated tubes, (Fig. 14,) and set aside for twenty-four hours, at the end of which time note the amount of precipitate. Daily comparisons can in this way be readily effected.

IV. *The Volumetric Method.*—This process, devised by Bödeker, depends upon the fact that ferrocyanide of potassium precipitates albumen from a solution containing acetic acid, in the atomic proportions of 211 ferrocyanide to 1612 albumen. The following description of the necessary manipulations is slightly modified from that given by Sutton:*

Mix an ounce of filtered urine with an equal volume of ordinary acetic acid. Next take four or five small filters of close texture, and adapt them to as many funnels; moisten with a little acetic acid, and fill them with boiling water. This will facilitate the subsequent filtrations. Fill a burette with the S.S. of ferrocyanide, (p. 21.) Now transfer with a pipette a fluid drachm of the acidulated urine into a small beaker, and add say 50 grains of S.S. from the burette. Shake well, and throw upon the first filter. If the filtrate is bright and clear, the ferrocyanide is in excess, and a drop of urine added to it will cause a precipitate; if, on the other hand, there is not enough ferrocyanide, the mixture will filter

* Sutton. Op. cit. p. 223.

more slowly, and the filtrate will be a little turbid. In this case, the addition of either ferrocyanide or urine may increase the turbidity. In testing the filtrate for excess of ferrocyanide, care must be taken not to add too much of the urine, lest the precipitate of hydro-ferrocyanide of albumen should dissolve in the excess of albumen.

According to the result obtained from the first filter, a second trial is made, with the same amount of urine, but increasing or diminishing the ferrocyanide, as may be necessary, and so on, until the conditions first observed are reversed. A trial of the mean between this quantity and the previous one will bring the estimation closer, so that a final test may be conclusive.

Example:

Acidulated Urine.	S.S.	In Filtrate.	
		Urine gave	S.S. gave
1st 3i.	50	Prec.	•0
2d 3i.	30	Prec.	0
3d 3i.	20	0	Prec.
4th 3i.	25	0	0

Hence, one drachm of acidulated urine = \circ a half-drachm of pure urine—contained .25 gr. of albumen, or four grains to the ounce.

SUGAR.

Next to albumen, the most important abnormal ingredient of urine is sugar. Its *presence* may be detected by several methods, the favorites being Trommer's, Fehling's, and the Fermentation-test.

Trommer's test may be performed as follows: Pour a small quantity of the suspected urine into a test-tube; add a drop or two of a solution of sulphate of copper, and to this about half as much liq. potassæ as there is urine. Upon shaking, the mixture becomes of a homogeneous dark-blue color. The mixture is then raised to the boiling-point, and, if sugar is present, a pale yellowish-brown precipitate of the suboxide of copper appears. If albumen is present, the above reaction will not take place; hence, this fact must be ascertained in advance, and the albumen, if present, be separated by coagulation and filtration.

Fehling's test, preferred by many, may be performed as follows: Introduce into a test-tube one volume of the copper and two volumes of the soda solutions, (p. 21.) Shake well, raise the mixture to

the boiling-point, and add the suspected urine in small quantities at a time. In ordinary diabetic urine the first few drops will produce a brilliant reddish or yellowish opaque precipitate. If the urine be added to about the volume of the test-liquid, and the mixture be again brought to the boiling-point without any precipitate, it is certain that no sugar is present.

Fermentation-test.—Put a little good yeast into a test-tube, and then fill it with the suspected urine. Close the mouth of the tube with the finger, and invert it into a vessel containing a considerable quantity of the same urine; remove the finger, without permitting air to enter the tube, and support it in a vertical position by means of a small wire triangle. Set the apparatus in a warm place for twenty-four hours. If sugar be present, it will be decomposed by fermentation into alcohol and carbonic acid, the gas rising to the top of the tube and displacing the fluid. This test is reliable, provided the yeast is good and the temperature suitable. These

points can be ascertained by preparing a companion tube containing a solution of grape-sugar, together with a little yeast, and setting it beside the tube containing the urine. If gas rises in both tubes, there is sugar in the urine; if no gas rises in the urine-tube, but does in the other, there is no sugar in the urine; while, if no gas rises in either tube, the yeast or the temperature are at fault, and the experiment must be repeated under more favorable circumstances.

Quantitative Determination of Sugar.—In order to *conveniently* estimate the quantity of sugar in a specimen of diabetic urine, several methods have been proposed, none of which possess absolute accuracy; but the results are sufficiently near the truth to permit of their employment for clinical purposes.

Fehling's Method.—The formula for the S.S. to be used in this test has already been given, (p. 21.) Two hundred fluid grains of this solution are introduced into a flask, and diluted with two or three

volumes of distilled water. The flask is then supported above a spirit-lamp or Bunsen burner, (Fig. 15,) and heated. It is well to let the flask rest upon a piece of wire-gauze, as the heat is thereby more evenly distributed. A certain quantity of urine is now taken, and is diluted either with four or with

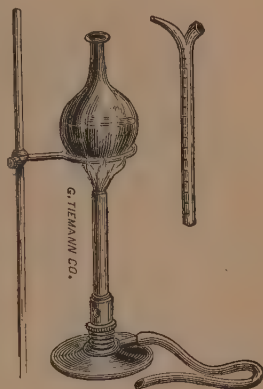


Fig. 15.

nine volumes of distilled water, according as it is supposed to contain much or little sugar. This diluted urine is then transferred to a burette. When the copper solution has reached the boiling-point, the flask is brought under the burette, and a small portion of the dilute urine is delivered into it. If, upon again heating, the blue color be not discharged, make fresh additions of urine, and continue the process, adding small portions at a time, until the last trace of blue disappears. When this occurs, examine the burette and calculate the result.

Example:

A specimen of urine was diluted with four volumes of water, and 175 grs. of the mixture were found necessary to reduce the 200 grs. of S.S. Hence, 175 grs. dilute urine = 35 grs. pure urine, contained one gr. of sugar. The proportion per fluid ounce is readily obtained: $35:1::456:13$ grs. per fluid ounce.

Roberts's, or the Specific Gravity Method.—Dr. Wm. Roberts has proposed the following process:

1st. Four ounces of saccharine urine are placed in a twelve-ounce vial with some yeast, and the mouth of the vial closed with a nicked cork, to permit the escape of gas.

2d. A companion-vial containing some of the same urine, without the yeast, and tightly corked, is placed beside the other, in a warm place. After fermentation has ceased, the specific gravity of the two specimens is ascertained with the urinometer. Dr. Roberts states that each degree of specific gravity lost by the fermented specimen indicates one grain

of sugar per fluid ounce of urine, and considers the method sufficiently accurate for clinical purposes.*

The method by *circumpolarization*, although one of the most accurate and convenient processes known, will not be described, as the cost of the necessary instrument precludes its coming into ordinary clinical use, and the instrument, when sold, is usually accompanied with full directions for its employment.

BILE.

The presence of bile in urine may sometimes be ascertained by the very simple process of shaking the urine in a partially-filled bottle, and regarding the froth or bead upon the surface. If the bead is yellow, it is due to the presence of bile, as the bead of normal urine is white, however yellow the urine itself may be. This method, however, will not answer if the bile be present in very small quantity, and it will be necessary to employ some more delicate procedure. We copy the following from Flint: †

*It must be remembered that the fluid ounce, Imperial measure, weighs about 18 grs. less than the fluid ounce U. S.

† Flint. Op. cit. p. 39.

“The presence of the *coloring matter* of the bile is usually indicated by the characteristic tint, more or less strongly marked, in the urine. A simple and certain test is to spread a thin stratum of the urine upon a porcelain surface, and to add to it a drop of nitroso-nitric acid, (a mixture of nitrous with nitric acid.) If *biliverdine* be present, the drop of acid will be fringed with a rapidly-varying play of colors, (violet, green, and red,) which speedily disappear. A drop of nitric acid will produce nearly the same appearance, though the colors are less strongly marked.”

The presence of the *biliary acids* may sometimes be detected in urine by Pettenkofer's test, which consists in adding to a little urine in a test-tube a drop or two of a strong solution of grape-sugar, (one to four.) Pure concentrated sulphuric acid is then to be added, drop by drop; if this is followed by the production of a red color, changing, after some minutes, to purple, the presence of the biliary ingredients may be assumed. It must be remembered, however, that albumen in urine will, under some cir-

cumstances, give the same result, as also, according to Thudichum,* will cerebrie and lithofellic acids.

Neubauer† modifies the details for the performance of Pettenkofer's test in the following manner: Evaporate to dryness a few drops of the suspected urine in a small porcelain capsule, over the water-bath; add a small drop of sugar-solution, (1 to 500,) and to this a similar drop of concentrated sulphuric acid. Warm the mixture for a few minutes upon the water-bath, and if the biliary acids be present, a reddish-violet hue will appear; the moment this tint is observed, remove the capsule from the water-bath and allow it to cool. While cooling, the reaction will increase in intensity. Neubauer states that this method is capable of detecting extremely minute quantities of the biliary ingredients.

Strasbourg‡ offers the following modification: A little cane-sugar is dissolved in a small quantity of the suspected urine, and a strip of bibulous paper is

* Thudichum. *Chemical Physiology*, p. 19.

† Neubauer and Vogel. *Op. cit.* Sixth edition. P. 88.

‡ Pflüger's *Archiv.* IV. 1871.

immersed in the mixture, and afterward removed and dried. When dry, a drop of pure concentrated sulphuric acid is placed upon the paper, and, if the biliary acids be present, a bright violet color is perceived by transmitted light.

CHAPTER VII.

DETECTION OF MEDICINAL AND OTHER SUBSTANCES IN THE URINE.

A VERY large number of medicinal substances are excreted in part or wholly by the kidneys, and are detectable in their secretion. Concerning the majority of these, it may be said that their detection is rarely of clinical importance, and many of the necessary procedures are difficult and tedious. A few, however, of the more simple will be given.

IRON.

Detection of Iron by the Wet Way.—The description of the following process is taken from Marais:*

Take from two to four drachms of urine, and evaporate to dryness. Then gradually heat to redness, until the contents of the capsule are completely

* Marais. Op. cit. p. 139.

blackened; remove from the flame and cool. When cold, gather the carbonaceous mass to the centre of the capsule with a small wooden or platinum spatula,* and add perfectly pure hydrochloric acid. Triturate the acid thoroughly with the carbon, and let the mixture stand for ten minutes. Then add half as much distilled water as there is acid, and boil for a few moments, triturating as before. When cold, filter, and divide the filtrate into two portions.

1st. To one portion of the filtrate add carbonate of soda to neutralization, and then add, drop by drop, a solution of ferrocyanide of potassium, (one to ten.) If the liquid turn blue, we may know that a ferrocyanide of Iron has formed.

2d. To the other portion, add one or two drops of nitric acid, and boil. When cold, add drop by drop a solution of sulphocyanide of potassium, (one to ten.) If iron be present, a bright reddish-brown

* Messrs. Tiemann & Co. have, at our suggestion, made some spatulæ of irido-platinum, which, on account of their stiffness, are preferable to those of pure platinum, and are admirably adapted to various chemical and microscopical manipulations.

precipitate of sulphocyanide of Iron will immediately appear.

Marais lays stress upon the importance of testing the hydrochloric acid before use, as much that is sold for pure contains notable traces of iron.

In performing the above tests, we have much more frequently obtained a positive result with the *sulpho*-cyanide than with the *ferro*-cyanide, which may be due to the acknowledged greater delicacy of the former test, or else to some error of manipulation in the performance of the latter.

Detection of Iron by the Blowpipe.—This method, however, is the one we usually employ, and may be performed as follows: Evaporate half an ounce of urine to dryness, and incinerate the residue. Take a piece of fine platinum wire, and make a small loop at its end. Make the loop red-hot in the flame of a blowpipe, and dip it hot into powdered borax. Sufficient borax will adhere to the wire, and, upon again heating, will fuse into a transparent, colorless bead. If the bead be again heated, and brought in contact with the urine-ash, a portion of the latter

will adhere. This is again heated, and the operation repeated until a considerable portion of the ash has been taken up by the bead. Now, if iron be present, the bead when *warm* will be *yellow* and transparent, and when cold, colorless.* If iron is present in large quantity, the borax bead is red when warm, and yellow when cold; we have not, however, met with this in urine. Although this reaction before the blowpipe is not peculiar to iron, it will not be counterfeited by any substance likely to be met with in urine.

Harley† states that urohæmatin contains iron in appreciable quantities, and that, in the ashes of this substance, it may be detected without difficulty, which fact, among others, leads him to suppose that urohæmatin is derived from the coloring matter of the blood, and its occurrence in urine in undue proportion to be the result and the evidence of excessive destruction of red blood-corpuscles. This,

* Sometimes it is white and opaque, from the presence of certain urinary salts.

† Harley. Op. cit. pp. 101 and 102.

however, does not invalidate the tests given, as they are not sufficiently delicate to detect the minute quantity of iron present in normal urine; and its detection, by means of them, would seem to indicate that the iron came from without; or, possibly, that the red corpuscles were being destroyed with unaccustomed rapidity.

LEAD.

Vogel* states that the search for lead in urine is difficult and not always successful. Ollivier, however, gives the following process:

The urine suspected to contain traces of a soluble compound of lead is treated with nitric acid, evaporated to dryness, and burned to an ash. The ash is mixed with distilled water, left to repose for several hours, and then thrown upon a double filter. A few drops of hydrosulphide of ammonium are added to the filtrate, and the precipitate is collected, washed, and dried. This precipitate is treated with nitric acid and heated. The solution is then

* Neubauer and Vogel. Op. cit. Sixth edition. P. 282.

diluted with distilled water and again filtered. The filtrate is concentrated on the water-bath, and, when cold, a little iodide of potassium in solution is added. A yellow precipitate of iodide of lead indicates the presence, in the urine, of this latter substance.

MERCURY.

Byasson* gives the following simple method of detecting this substance in urine. The process is as follows: Wrap a piece of gold-foil round a small piece of tin, and introduce it into a beaker containing the suspected urine, previously acidulated with hydrochloric acid. At the end of twenty-four hours, remove the gold, wash it carefully with distilled water, and dry it with bibulous paper. It should then be introduced into a small copper tube, the mouth of which is loosely stopped with cotton, below which is fastened a piece of test-paper.

The test-paper is made by preparing a solution of the following constitution: Water, 100 parts; chloride of gold sodium, 0.6 of a part; bichloride of pla-

* Jour. de l'Anatomie et de la Physiologie, (Robin.) 1872.

tinum, 0.4 of a part. A quill-pen dipped in this solution is used to trace upon white paper a few lines or marks. The test-paper being in position, the copper tube is then brought over the flame of an alcohol lamp. The heat will volatilize any mercury present, which, coming in contact with the paper, reduces the test-fluid, causing purplish or black marks to appear upon the paper where the tracings have been made.

APPENDIX.

TABLE I.

Table showing the approximate composition of an average specimen of normal urine.

Urea.....	8.00 grains per fluid ounce.
Uric Acid.....	0.25 " " " "
Phosphoric Acid.....	1.50 " " " "
Sulphuric Acid	1.00 " " " "
Chloride of Sodium.....	2.50 " " " "

TABLE II.

Table for Conversion of the Fahrenheit Thermometer Scale into that of the Centigrade, and vice versâ.

F.	C.	F.	C.	F.	C.
32	0.00	55	12.78	78	25.55
33	0.55	56	13.33	79	26.11
34	1.11	57	13.89	80	26.67
35	1.67	58	14.44	81	27.22
36	2.22	59	15.00	82	27.78
37	2.78	60	15.55	83	28.33
38	3.33	61	16.11	84	28.89
39	3.89	62	16.67	85	29.44
40	4.44	63	17.22	86	30.00
41	5.00	64	17.78	87	30.55
42	5.55	65	18.33	88	31.11
43	6.11	66	18.89	89	31.67
44	6.67	67	19.44	90	32.22
45	7.22	68	20.00	91	32.78
46	7.78	69	20.55	92	33.33
47	8.33	70	21.11	93	33.89
48	8.89	71	21.67	94	34.44
49	9.44	72	22.22	95	35.00
50	10.00	73	22.78	96	35.55
51	10.55	74	23.33	97	36.11
52	11.11	75	23.89	98	36.67
53	11.67	76	24.44	99	37.22
54	12.22	77	25.00	100	37.78

TABLE III.

Table for the Conversion of the Millimetre Barometer Scale into that of English Inches.

MM.	Inch.	MM.	Inch.	MM.	Inch.
700	27.560	730	28.741	760	29.922
701	27.590	731	28.780	761	29.961
702	27.638	732	28.819	762	30.000
703	27.678	733	28.859	763	30.040
704	27.717	734	28.898	764	30.079
705	27.756	735	28.938	765	30.119
706	27.795	736	28.977	766	30.158
707	27.835	737	29.016	767	30.197
708	27.876	738	29.056	768	30.237
709	27.914	739	29.095	769	30.276
710	27.953	740	29.134	770	30.315
711	27.992	741	29.174	771	30.355
712	28.032	742	29.213	772	30.384
713	28.071	743	29.252	773	30.434
714	28.111	744	29.292	774	30.473
715	28.150	745	29.331	775	30.512
716	28.189	746	29.371	776	30.552
717	28.229	747	29.410	777	30.591
718	28.268	748	29.449	778	30.631
719	28.308	749	29.489	779	30.670
720	28.347	750	29.528	780	30.709
721	28.386	751	29.567	781	30.749
722	28.426	752	29.607	782	30.788
723	28.465	753	29.646	783	30.827
724	28.504	754	29.685	784	30.867
725	28.543	755	29.725	785	30.906
726	28.583	756	29.764	786	30.945
727	28.622	757	29.804	787	30.983
728	28.661	758	29.843	788	31.024
729	28.701	759	29.882	789	31.063

1 millimetre=0.03937 inch.

1 inch=25.39954 mm.

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Urea Tube.....	2 00
Filters, German and Swedish, assortment.....	75
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Measuring Pipettes, f 3 ss, f 3 i, f 3 ij.....	50
Balance, (Becker's,) turning with $\frac{1}{10}$ grain.....	11 00
“ same as above, but in a glass case.....	22 00
Weights, (accurate,) 10 grains to $\frac{1}{10}$ grain.....	1 75
“ best quality, 1000 grains to $\frac{1}{100}$ grain.....	10 00
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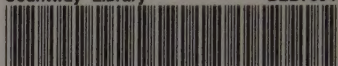
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